



US008060143B2

(12) **United States Patent**  
**Cho et al.**

(10) **Patent No.:** **US 8,060,143 B2**  
(45) **Date of Patent:** **\*Nov. 15, 2011**

(54) **COMBINED BASE TRANSCEIVER STATION AND BASE STATION CONTROLLER**

(75) Inventors: **Wonjun Cho**, Lantana, TX (US); **Jeom Sik Kim**, Coppell, TX (US); **Myoung Chul Choi**, Plano, TX (US); **Hyunung Cha**, Plano, TX (US); **Jefferson K. Kim**, Plano, TX (US); **Hyeon Bong Park**, Plano, TX (US); **Jae Hong Park**, Plano, TX (US); **Seong Ju Seo**, Allen, TX (US); **Jae Kyu Yoo**, Richardson, TX (US); **Jake J. Han**, Coppell, TX (US)

(73) Assignee: **Airwalk Communications, Inc.**, Richardson, TX (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/037,063**

(22) Filed: **Jan. 18, 2005**

(65) **Prior Publication Data**

US 2005/0159186 A1 Jul. 21, 2005

**Related U.S. Application Data**

(60) Provisional application No. 60/537,408, filed on Jan. 16, 2004, provisional application No. 60/537,419, filed on Jan. 16, 2004.

(51) **Int. Cl.**  
**H04B 1/38** (2006.01)

(52) **U.S. Cl.** ..... **455/560; 455/561; 370/352; 370/401**

(58) **Field of Classification Search** ..... 455/436, 455/561, 560, 422.1, 424, 426.1, 426.2, 433, 455/428, 439, 448-450, 466; 370/328, 329, 370/331, 335, 341, 352, 400, 401  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,428,602	A *	6/1995	Kemppainen	370/330
6,070,073	A	5/2000	Maveddat et al.	
6,396,820	B1 *	5/2002	Dolan et al.	370/328
6,519,457	B1 *	2/2003	Jiang et al.	455/442
6,597,912	B1	7/2003	Lu et al.	
6,625,153	B1 *	9/2003	Liu	370/395.1
6,694,134	B1 *	2/2004	Lu et al.	455/419
6,721,333	B1 *	4/2004	Milton et al.	370/469
6,782,035	B1 *	8/2004	Nakamura et al.	375/130
6,885,668	B1 *	4/2005	Lee et al.	370/395.1
6,993,359	B1 *	1/2006	Nelakanti et al.	455/554.1
7,031,747	B2	4/2006	Cyr et al.	
7,099,291	B2 *	8/2006	Harris et al.	370/335
7,127,248	B1	10/2006	Costa et al.	
7,133,672	B2 *	11/2006	Sayeedi	455/432.1
7,266,130	B2 *	9/2007	Lee et al.	370/466
7,299,052	B2 *	11/2007	Ji et al.	455/452.1

(Continued)

FOREIGN PATENT DOCUMENTS

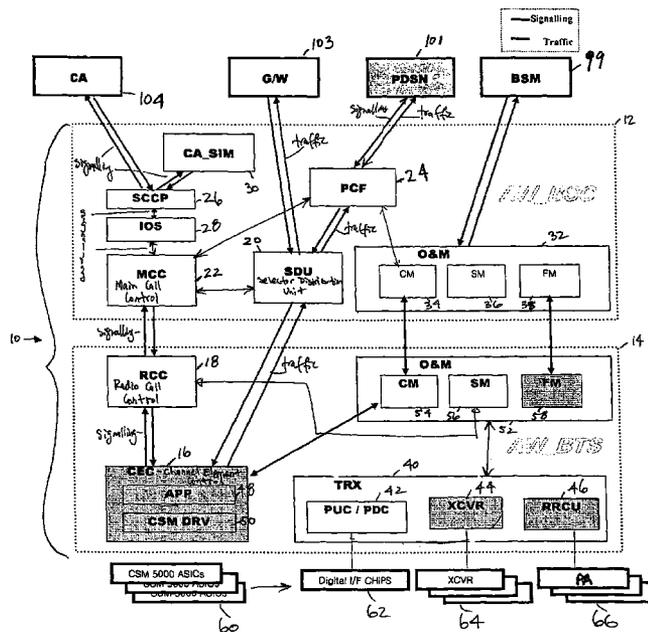
WO WO 03/034759 A 4/2003

Primary Examiner — Anthony Addy

(57) **ABSTRACT**

A combined base station controller (12) and base transceiver station (14) comprises a selector distribution unit (SDU, 20), a main call control (MCC, 22) coupled to the SDU, a radio call control (RCC, 18) coupled to the MCC, and a channel element control (CEC, 16) coupled to the RCC.

**20 Claims, 3 Drawing Sheets**



U.S. PATENT DOCUMENTS

7,319,872	B2 *	1/2008	Krishnamurthi et al. ....	455/442	2004/0110512	A1	6/2004	Lim	
7,548,530	B2 *	6/2009	Diaz Cervera et al. ....	370/338	2004/0203957	A1	10/2004	George	
2001/0038615	A1 *	11/2001	Chang .....	370/329	2005/0037727	A1 *	2/2005	Kansal et al. ....	455/343.1
2001/0046214	A1 *	11/2001	Kang .....	370/328	2005/0101329	A1	5/2005	Gallagher	
2002/0085532	A1	7/2002	Kim		2005/0135420	A1 *	6/2005	Chamberlain .....	370/474
2003/0032451	A1	2/2003	Hu		2005/0186948	A1	8/2005	Gallagher et al.	
2003/0040315	A1 *	2/2003	Khaleghi et al. ....	455/435	2005/0276273	A1 *	12/2005	Oprescu-Surcobe et al.	370/401
2003/0119518	A1	6/2003	Cleveland et al.		2007/0014281	A1	1/2007	Kant	
2003/0223393	A1 *	12/2003	Lee .....	370/335	2007/0238448	A1	10/2007	Gallagher et al.	
2004/0001474	A1	1/2004	Simelius		2007/0243872	A1	10/2007	Gallagher et al.	
2004/0042410	A1 *	3/2004	Harris et al. ....	370/252	2007/0254648	A1	11/2007	Zhang et al.	

\* cited by examiner

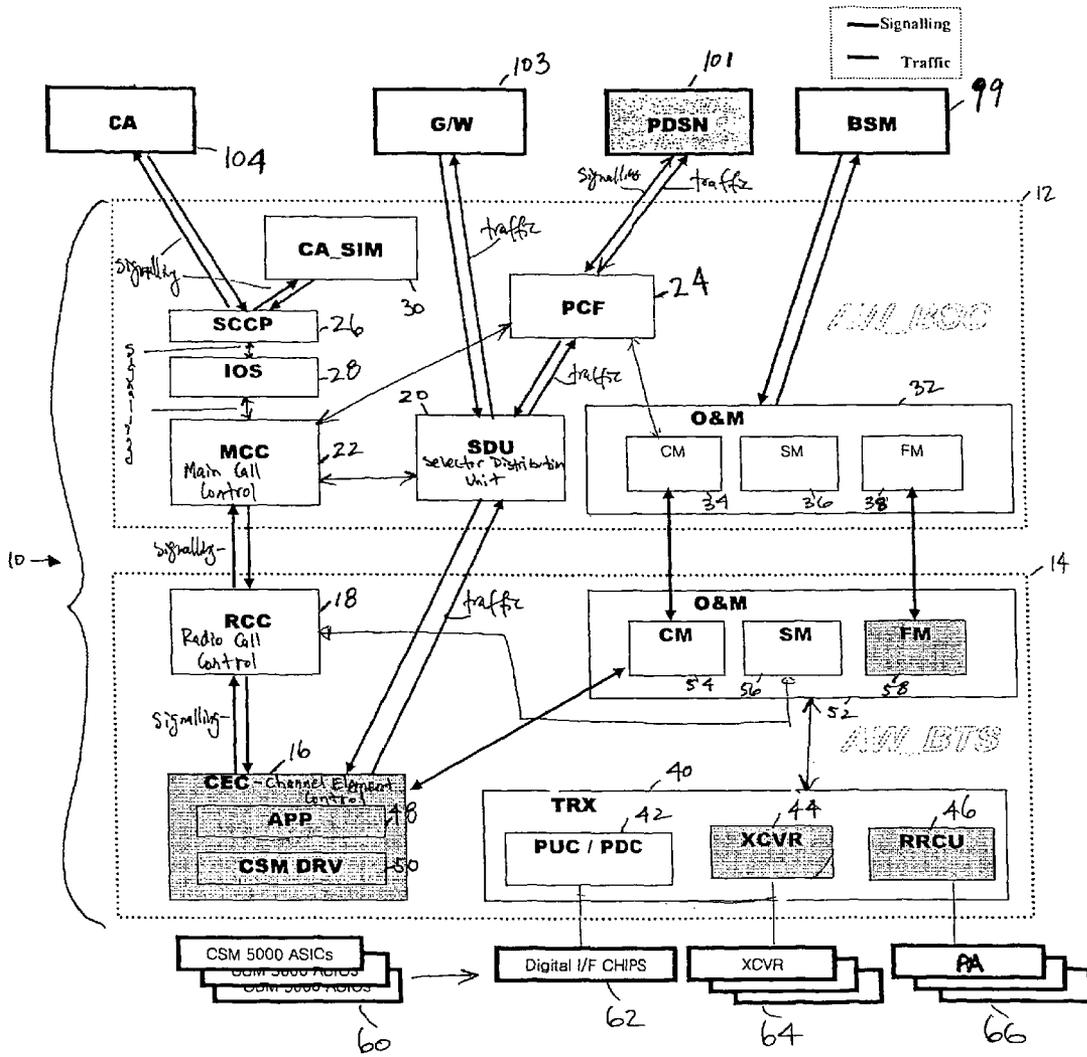


FIG. 1

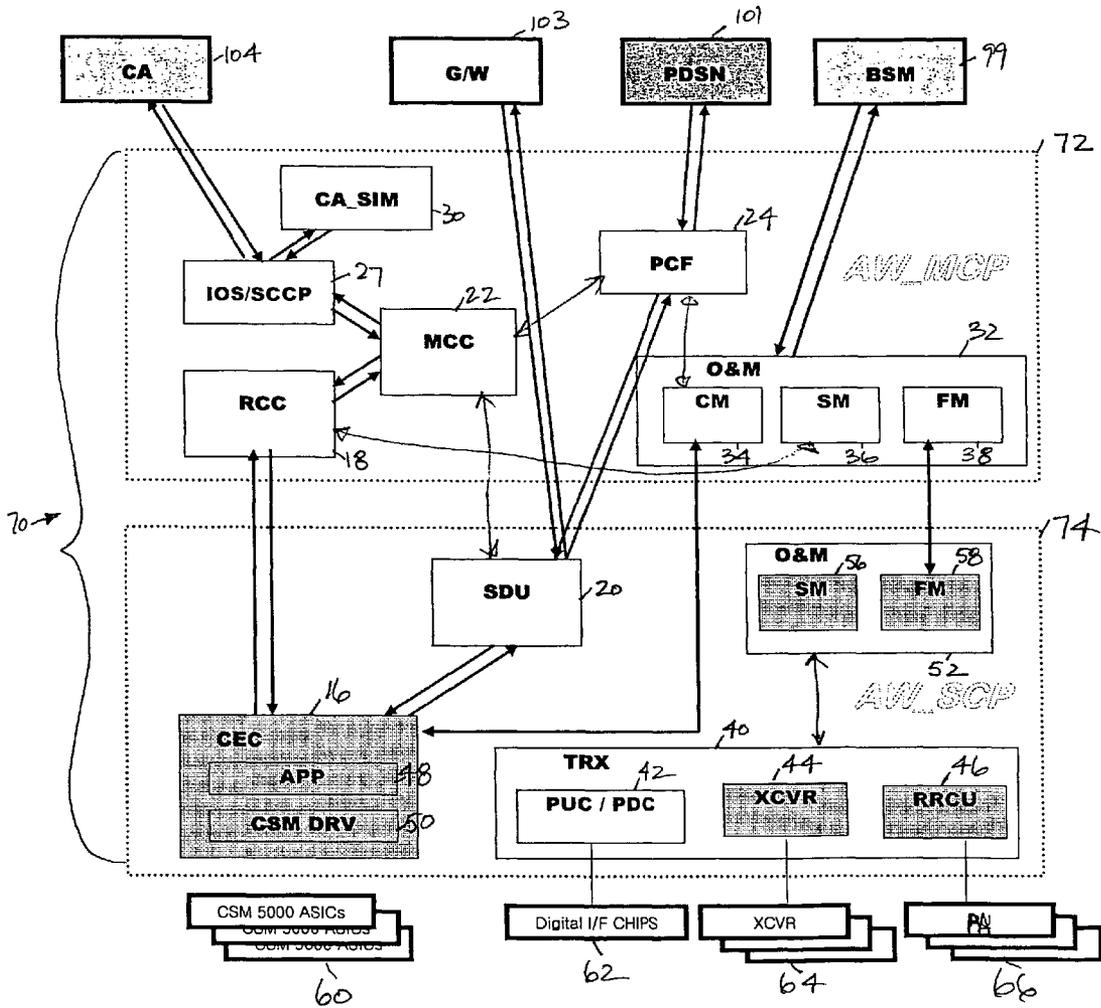


FIG. 2

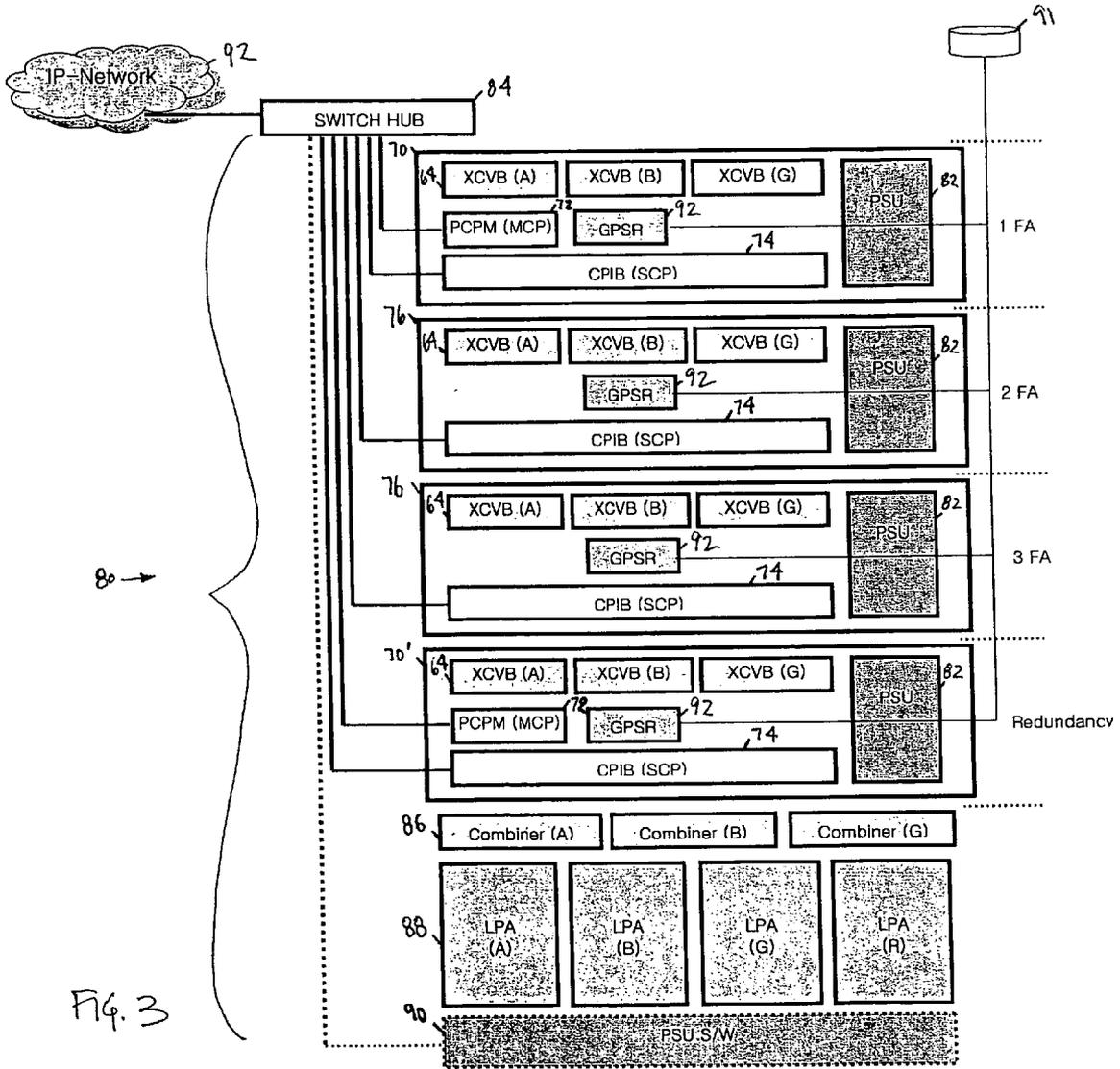


FIG. 3

## COMBINED BASE TRANSCEIVER STATION AND BASE STATION CONTROLLER

### CROSS REFERENCE TO RELATED APPLICATIONS

The present patent application is related to and claims the benefit of provisional patent application No. 60/537,408, filed on Jan. 16, 2004, entitled CDMA Radio Access Network System and Method, and provisional patent application No. 60/537,419, filed on Jan. 16, 2004, entitled CDMA IP Base Transceiver Station, the contents of which are enclosed by reference herein. The present patent application is further related to patent application Ser. No. 11/037,813 entitled Combined Base Transceiver Station and Base Station Controller Call Origination And Termination, patent application Ser. No. 11/037,814 entitled Combined Base Transceiver Station and Base Station Controller Handoff, patent application Ser. No. 11/037,386 entitled Combined Base Transceiver Station and Base Station Controller Data Call, patent application Ser. No. 11/037,387 entitled Combined Base Transceiver Station and Base Station Controller Data Call And Quality Of Service, and patent application Ser. No. 11/037,388 entitled Combined Base Transceiver Station and Base Station Controller Optimized Assignment Of Frame Offsets, each of which is assigned to the assignee of the present invention and is filed on even date herewith.

### BACKGROUND OF THE INVENTION

The present invention is related to a base transceiver station and a base station controller, and, more specifically to a combined base transceiver station and a base station controller.

Current cellular operators predominantly provide services via very large or macro coverage areas. Limitations encountered by these operators include the difficulty of providing reliable in-building or campus coverage. Such coverage should provide subscribers with seamless services at a particular quality level, and should provide operators with additional revenue sources.

Therefore, what is needed is a wireless solution that overcomes the aforementioned limitations by providing a micro solution that compliments the wireless macro network by providing increased voice and data capacity and coverage.

### SUMMARY OF THE INVENTION

The present invention provides a radio access network (RAN) system (which contains a base transceiver station and a base station controller integrated into a single compact platform) for wireless coverage and in-building services, as well as for providing additional capacity in a macro network when it comes to filling "hotspots." Such a RAN system, which preferably operates in or in conjunction with a CDMA network, supports signaling, traffic, handoff, power, and control, while providing multiple interfaces to the core network.

In one embodiment, a combined base station controller and base transceiver station comprises a selector distribution unit (SDU), a main call control (MCC) coupled to the SDU, a radio call control (RCC) coupled to the MCC, and a channel element control (CEC) coupled to the RCC.

In another embodiment, a combined base transceiver station (BTS) and base station controller (BSC) comprises a selector distribution unit (SDU), a main call control (MCC) coupled to the SDU, wherein the BSC includes the SDU and the MCC, a radio call control (RCC) coupled to the MCC, and

a channel element control (CEC) coupled to the RCC and to the SDU, wherein the BTS includes the RCC and the CEC.

In a further embodiment, a system comprises a first module including a control portion and a device portion, wherein the control portion includes a radio call control (RCC) module coupled to a main call control (MCC) module, wherein the device portion includes a selector distribution unit (SDU) coupled to a channel element control (CEC) module, and a second module, coupled to the first module, including a device portion.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a radio access network (RAN) in accordance with a preferred embodiment of the present invention;

FIG. 2 depicts a stackable RAN in accordance with a preferred embodiment of the present invention; and

FIG. 3 depicts a further stackable RAN in accordance with a preferred embodiment of the present invention.

### DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, radio access network (RAN) 10 comprises a base station controller (BSC) 12 and a base transceiver station (BTS) 14 that comprise a number of blocks or modules. These blocks or modules are software, hardware, firmware, and/or a combination of software, hardware, and/or firmware. The BSC 12 comprises a selector distribution unit (SDU) 20 coupled to a main call control (MCC) 22 and to a packet control function (PCF) 24 which is also coupled to the MCC 22, a signaling control connection part (SCCP) 26 coupled to an interoperability system (IOS) 28 which is also coupled to the MCC 22, a call agent simulator (CA\_SIM) 30 which is coupled to the SCCP 26, and an operation, administration, and maintenance (OA&M) 32 module coupled to the PCF 24.

#### Main Call Control (MCC) 22

The MCC 22, which performs the operations that pertain to individual subscribers including registration, call setup, call release, handoff and other subscriber features, is associated with the following functionality:

#### Registration

Mobile registration is a process where mobile characteristics such as location or status are provided to the network. Registration may be initiated by a mobile station (MS, not shown), by a network, or implied during access by the MS. To support these features, the MCC 22 interfaces with a radio call control module (RCC) 18, which will be described further below, and with a call agent (CA) 104. The CA 104 is preferably a soft switch whose functions include call processing, supplementary service, registration, interacts with a Home Location Register (HLR) in the macro network, and provides common PBX functions.

#### Mobile Originated Call Setup for Voice and Circuit Data Calls

The MCC 22 receives an Origination Message from the MS via the RCC 18 and then communicates with CA 104 to request call service, confirm the validity of the MS, as well as get the resource information from a media gateway (MG, not shown). The MG mediates the elements between circuit switched voice networks and an IP network. For example, the MG relays voice, fax, modem and data traffic over the IP network. The MCC 22 interfaces with the RCC 18 to request a radio resource and with the SDU 20 to allocate a selector resource.

Mobile Terminated Call Setup for Voice and Calls and Circuit Data Calls

The MCC 22 receives a Paging Request message from the CA 104 and passes it to the RCC 18 to initiate a mobile terminated call setup scenario. The MCC 22 receives a Page Response Message then communicates with the CA 104 to get the resource information from the MG and indicate for the call to be answered at the MS. The MCC 22 interfaces with the RCC 18 to request a radio resource and with the SDU 20 to allocate a selector resource.

Call Clearing of Voice and Circuit Data Calls

Call clearing may be initiated by either the MS, the SDU 20 or the CA 104. The MCC 22 sends clear messages to the SDU 20 or to the CA 104 and releases internal resources.

Mobile Originated Call Setup for Packet Data Calls

The MCC 22 receives an Origination Message from the MS via the RCC 18 with a data rate to send set to 'true' (DRS=1) and a packet data service option, and then communicates with the CA 104 to request packet data service and confirm the validity of the MS. The MCC 22 interfaces with the PCF 24 to setup a connection to a packet data serving node (PDSN) 101, which exchanges packets with the MS over the radio and the other IP networks, with the RCC 18 to request a radio resource, and with the SDU 20 to allocate a selector resource.

Reactivation of Packet Data Calls

The MCC 22 supports either the MS initiated or network initiated reactivation from a dormant state. With a MS initiated reactivation, a normal packet data call setup procedure in the MCC ensues, while with a network initiated reactivation, the MCC 22 sends a base station (BS, not shown) Service Request to the CA 104 to begin an initiated call setup as a request from the PCF 24. The BS, which is a fixed station that communicates with the MS, may be a cell, a sector within a cell, a mobile switching center (MSC), or other part of the wireless system.

Call Clearing of Packet Data Calls

Call clearing may be initiated by either the MS, the SDU 20, the CA 104 or the PCF 24. During a call clearing scenario, the MCC 22 sends clear messages to the SDU 20, the CA 104 and the PCF 24 and releases internal resources.

Transition to Dormancy for Packet Data Calls

If the MS transits to a Dormant State, the MCC 22 proceeds in a normal packet call release scenario and notifies the CA while setting the release cause to "packet call going dormant." The MCC 22 also supports Dormant Handoff.

Short Data Bursts

The MCC 22 supports a Short Data Burst which consists of a small number of frames that are transmitted to a MS with a dormant packet data service instance.

Inter-BS Handoff

The MCC 22 supports soft handoff, inter-frequency assignment (FA) hard handoff and intra-FA hard handoff. The MCC 22 interfaces with the RCC 18 to get radio resources as request from the SDU 20 and manages neighbor lists.

Inter-CA Hard Handoff

When the MCC 22 receives a handoff request message from the SDU 20 and the handoff type is inter-CA hard handoff, the MCC 22 sends a Handoff Required message to the CA 104 to initiate an inter-CA hard handoff as a serving part. If the MCC 22 receives a Handoff Request message from the CA 104, the MCC 22 initiates an inter-CA hard handoff scenario as a target part.

Terminal Authentication

Terminal authentication is the process by which information is exchanged between the MS and the network to confirm

the identity of the MS. The MCC 22 delivers relegated messages to the SDU 20, the RCC 18 and the CA 104.

Short Message Service

Short Message Service (SMS) is a mechanism of delivery of short messages over the mobile network. The MCC 22 supports messages and process for SMS mobile originated calls, SMS mobile terminated calls, and SMS Broadcast calls.

Supplementary Services

The MCC 22 supports various supplementary services including Message Waiting, Call Forwarding, Call Delivery, Call Transfer, Three Way Calling, and Conference Calling in terms of communicating with the RCC 18 using a Feature Notification Message or with the SDU 20 using Flash with an Information Message.

Test Calls

The MCC 22 initiates the test call process as a request from the base station manager (BSM 99) or on receiving an Origination Message with a look back service option from the MS.

Call Trace

The MCC 22 initiates the call trace process as a request from the WPM. The MCC 22 stores the related information to a buffer and starts a trace whenever the MS requests call service.

Selector Distribution Unit (SDU) 20

The SDU 20, which includes an air interface portion that processes air messages between the SDU and a MS, a router interface portion that processes messages between the SDU and other software blocks, and a portion that processes voice and data calls, is associated with the following functionality:

Multiplex and De-Multiplex

This function multiplexes and de-multiplexes user traffic and signaling traffic for the air interface.

Forward and Reverse Traffic Frame Selection and Distribution

This function is responsible for selecting the best quality incoming air interface reverse link frame involved in the soft handoff, and distributes forward air interface frames to all channel elements involved in a call.

Handoff Type Decision and Handoff Direction

This function decides a handoff type that will be processed including soft handoff, softer handoff, hard handoff, etc., and directs handoff processing to other software blocks such as the MCC 22 and a traffic channel element (TCE) in the CEC 16.

Process Radio Link Protocol (RLP) Procedures

A RLP Type 1, 2, and 3 is used with IS-95A/B or cdma2000 traffic channels to support CDMA data services. The RLP, which is a connection-oriented, negative-acknowledgement based data delivery protocol, provides an octet stream transport service over forward and reverse traffic channels. The RLP includes procedures to reduce the error rate exhibited by CDMA traffic channels.

Forward and Reverse Power Control

This function generates or utilizes relevant power control information that is exchanged over the air interface or the channel element.

Process Test Call Procedures

This function supports an MS loop-back call, such as a service option 2 and a service option 9 call.

Process Real Time Protocol (RTP) Procedures

This function is responsible for interfacing with a MG or other BSCs.

Process Signaling Layer 2 Procedures

This function performs the layer 2 functionality of the air interface signaling protocol and is responsible for the reliable delivery of the layer 3 signaling messages between the BSC and the MS.

Process Generic Routing Encapsulation (GRE) Procedures. This function is responsible for interfacing with the PDSN **101**.

#### Media Gateway (G/W) **103**

The SDU **20** receives data, formats it and then sends it to the G/W **103**. Similarly, data received from the G/W **103** can be formatted by the SDU **20**.

#### Signaling Control Connection Part (SCCP) **26**

The SCCP **26** is used to provide a referencing mechanism to identify a particular transaction relating to, for instance, a particular call. The current implementation of the A1 interface using TCP/IP protocol employs an SCCP implementation which provides the minimal functionality required to create the CALL context in which to pass IOS messages and monitor the TCP/IP connection. The SCCP **26** is associated with the following functionality:

##### TCP/IP Connection Establishment

The SCCP creates a TCP/IP socket as a client to communicate with the CA **104**.

##### Signaling Connection Establishment

A new transaction, such as location updating, or an incoming or outgoing call, is initiated on the radio path. Following an Access Request made by the MS on the access channel, the connection establishment is then initiated by the BS.

If the CA **104** decides to perform an inter-CA hard handoff, the connection establishment is initiated by the CA **104**.

##### Signaling Connection Release

This procedure is normally initiated at the CA **104** but in the case of abnormal SCCP connection release, the BS may initiate a connection clearing.

##### Interoperability System (IOS) **28**

The IOS **28** processes messages from the CA **104** or the MCC **22** and converts between internal message format and standard format. A Base Station Application Part (BSAP) is the application layer signaling protocol that provides messaging to accomplish the functions of the A1 Interface component of the CA-BS Interface. The BSAP is split into two sub-application parts: the BS Management Application Part (BSMAP), and the Direct Transfer Application Part (DTAP). The BSMAP supports all Radio Resource Management and Facility Management procedures between the CA **104** and the BS, or to a cell(s) within the BS. BSMAP messages are not passed to the MS, but are used to perform functions at the CA **104** or the BS. A BSMAP message (Complete Layer 3 Information) is also used together with a DTAP message to establish a connection for a MS between the BS and the CA **104**, in response to the first layer 3 air interface message sent by the MS to the BS for each MS system request. The DTAP messages are used to transfer call processing and mobility management messages between the CA **104** and BS. DTAP messages carry information that is primarily used by the MS. The BS maps the DTAP messages going to and coming from the CA from/into the appropriate air interface signaling protocol.

The IOS **28** is associated with the following functionality:

##### Encoding Messages

The IOS messages proprietary format from the MCC **22** as the A interface specifications for sending to the CA.

##### Decoding Messages

The IOS **28** converts messages from the CA **104** to internal messages.

##### Packet Control Function (PCF) **24**

The PCF **24** is a packet control function to manage the relay of packets between the BS and the PDSN **101**. In a cdma2000 wireless network, access to packet data services is provided by the PDSN **101**. The PCF **24** provides call processing functionality within the Radio Access Network (RAN) interfaces with the PDSN **101** and interfaces with the MCC **22** and

the SDU **20** to provide internal signaling and packet delivery. The interface between the PCF **24** and the MCC **22** is called the A9 interface and the interface between the PCF **24** and the SDU **20** is the A8 interface. The interface between the PDSN **101** and the PCF **24**, which is the interface between the radio and packet network, is known as the R-P interface or the A10/A11 interface.

The PCF **24** is associated with the following functionality: Main Processing which creates tasks and receives messages over IP, Message Processing which generates and extracts message by packing and unpacking, A10/A11 Processing which processes the A10/A11 interface, A8/A9 Processing which processes the A8/A9 interface, Hash Processing which performs the MD5 hashing function, Timer Processing which handles timer set, timer cancel, and timeout processing, Utility for primitives and debugging commands, and Call Control for call processing of originating, terminated and handoff calls.

##### Call Agent Simulator (CA SIM) **30**

For wireless voice and data communications, various components, such as the CA **104** in the core network and the IP-BS in the Radio-Access Network, are necessary components. The installation of other components in the core network, such as the CA **104**, a HLR, etc., constitutes a large expense. To increase the efficiency and flexibility, a CA-simulator **30** can be provided so that voice and data calls are possible without connecting to the CA **104** or to an HLR. As such, an IP-BS can be installed in a small wireless network without a CA or HLR.

##### Operation, Administration and Maintenance (OAM) **32**

The OAM block **32** is associated with the following functionality: a Configuration Management (CM) block **34** that configures each block or module of the BSC **12** based on program load data (PLD) information (which includes parameters, such as a system ID, an IP address, etc., to configure the system) which can be downloaded from a server, a Status Management (SM) block **36** that obtains a status of the BSC **12** and reports the status to the BSM **99**, and a Fault Management (FM) block **38** that checks and detects system faults or alarms and reports them to the BSM.

Referring again to FIG. 1, the radio access network (RAN) **10** further comprises a base transceiver station (BTS) **14**. The BTS **14** comprises a Channel Element Control (CEC) **16** coupled to the Radio Call Control (RCC) **18**, an Operation, Administration and Maintenance (OAM) **52** block coupled to the CEC, to the RCC, and to a Transmit and Receive Interface (TRX) **40**.

##### The Channel Element Control (CEC) **16**

The CEC block **16** controls the call processing to interface with the MS. The CEC also interfaces with upper layer blocks to handle over the air messages to set-up, maintain, and terminate voice and data calls. In order to make these calls, both signaling and traffic frames must be transmitted and received to and from the MS. It is also important for these frames to be transmitted and received at the right time with correct information. This is accomplished by using, for example, a modem chip, such as the Qualcomm CSM5000 modem chip **60**, I/F chips **62**, a transceiver **64** and a power amplifier **66**. The components **60-66** are predominantly hardware components that can be co-located within the RAN **10**. The CEC block **16** is associated with the following functionality:

##### Overhead Channel Configurations

The CEC **16** receives overhead channel configuration messages from the RCM and sets the parameters to the driver of the modem chip **60**.

#### Air Message Encapsulation and Transmission

The CEC 16 encapsulates and sends a frame for sync channel message transmission (at, for example, every 80 msec) and sends a frame for paging channel message transmission (at, for example, every 20 msec). To transmit each frame of the sync and paging channel, the CEC 16 revokes semaphores periodically by external interrupt request source.

#### CSM Built-in Test

The CEC 16 provides a built-in test function for the modem chip 60 which includes checking a register test, an interrupt test, as well as a reverse ARM test. This test can be performed by an operator's request to show if the modem chip 60 is functioning properly or not.

#### Forward and Reverse Power Control

The CEC 16 supports forward and reverse power control processing.

#### Process Time of Day (TOD) Message

The CEC 16 receives the TOD message via a GPS (at, for example, every 2 sec) and processes it to get the system time and GPS status.

#### Process Loopback Call Procedures

This function supports MS-BTS loop-back call. This function can show if air-interface between MS and BTS works well.

#### Process Traffic Channel Processing

The CEC 16 is responsible for assigning a traffic channel and clearing it by the order of RCC 18. When the traffic channel is setup, the CEC 16 delivers traffic packets between the SDU 20 and the MS.

#### Maintain Forward and Reverse Link

The CEC 16 checks the forward and reverse path and reports them to a status or statistics block.

#### Process High Speed Data Service

The CEC 16 is responsible for processing supplemental channel (SCH) packets for high speed data service which supports up to, for example, 128 kbps. The SCH packets are used if additional channels are needed to handle the transfer of the data.

#### Process Soft and Softer Handoff procedure

The CEC 16 is responsible for processing Soft and Softer Handoffs.

#### Provide H/W Characteristics Test Functionalities

The CEC 16 supports various hardware characteristics tests such as an access probe test, a AWGN test, etc. These tests determine if the RF or the IF properties of each of the basestations are in order to ensure (via, for example, a good path) that messages can be transferred.

The CSM application 48 is adapted to receive data from the CSM (or modem chip 60) Driver 50.

#### Radio Call Control (RCC) 18

The call control of the air interface is provided by the RCC 18. The air interface between the MS and the BTS 14 is specified by, for example, the TIA/EIA-95-A/B and the cdma2000 standards, which include the core air interface, minimum performance, and service standards. The functionalities of the RCC 18 consist of call processing, resource management, and supplementary services. The RCC 18 provides call processing functionality in order to setup and release call and resource management of radio resources such as CDMA channels, traffic channel elements, Walsh code channels, frame offsets, etc. The RCC 18 also provides signaling functionality by interfacing with other relevant software blocks.

The RCC 18 provides various processing functions including: Main Processing which creates tasks and receives messages over IP, Resource Management which processes resource allocation and de-allocation, Message Processing

which generates and extracts message by packing and unpacking, Initialization Processing which initializes buffers and variables, RCV. from RSCH processing which processes all messages on the reverse common signaling channel, RCV. from RDCH processing which processes some messages on the reverse dedicated signaling channel, RCV. from MCC processing which processes all messages from the MCC, SND. to FSCH processing which processes all messages sent to MS on the forward common signaling channel, SND. to FDCH processing which processes some messages sent to MS and CEC on forward dedicated signaling channel, SND. to MCC processing which processes all messages sent to the MCC, Layer 2 Processing which processes Layer 2 information, Hash Processing which performs the hash function to decide CDMA channel and Paging Channel number, Timer Processing which handles timer set, timer cancel, and timeout processing, and Utility which provides primitives and debugging commands.

#### Transmit and Receive Interface (TRX) 40

The TRX block 40 controls and diagnoses hardware devices in the BTS 14, and includes:

#### The PUC/PDC Block 42

The PUC/PDC 42 up-converts and down-converts between a baseband signal and an IF signal.

#### The Transceiver Control (XCVR) Block 44

The Transceiver Control Block (XCVR) 44 controls transceiver operations which carry IF signals to a carrier frequency band.

#### AMP Control Block

For high power amplification of the signal, the IP-BS provides the interface to the AMP. The AMP control block controls AMP operations such as ON/OFF.

#### Hardware Diagnostic Test Module

The diagnostic test module provides the functionalities for hardware characteristics test of pn3383 such as AWGN test, access probe test, etc. For example, the pn3383 test implements test environment conditions.

The power amplifier (PA) 66, via the RRCU 46, amplifies the output signal because the output of the XCVR 44 tends to be small. As such, a broader coverage area is possible.

Operation, Administration and Maintenance (OAM) block 52

The OAM block 32 is associated with the following functionality: a Configuration Management (CM) block 34 that configures each block or module of the BTS 14 based on program load data (PLD) information (which includes parameters, such as a system ID, an IP address, etc., to configure the system) received from the BSM (or IP-BS) 99, a Status Management (SM) block 36 that obtains a status of the BTS 14 and reports the status to the BSM, and a Fault Management (FM) block 38 that checks and detects system faults or alarms and reports them to the BSM.

Referring now to FIG. 2, the components of a stackable IP Radio Access Network (RAN) 70 are depicted. The blocks in the RAN 70 perform a similar functionality to their respective blocks in the RAN 10. Such a stackable RAN 70 provides increased bandwidth and redundancy without utilizing a card based expansion scheme as has been previously employed. Rather, the RAN 70 is modular and stackable (in a very small footprint) and includes a control portion (the Main Control Processor (MCP)) 72 and a device portion (the SDU/CEC Processor (SCP)) 74. With a centralized control portion 72, various device portions 74 can be utilized with a single control portion.

A difference between the RAN 70 and the RAN 10 is that the SDU 20 is now co-located with the CEC 16, and the RCC 18 is co-located with the MCC 22. As such, messaging

between these co-located blocks is decreased providing an increase in system performance.

Referring now to FIG. 3, a stackable configuration **80** of the RAN of the present invention is depicted. The configuration **80** includes a RAN **70** that includes a master MCP **72** and a RAN **70'** that includes a slave MCP **72**. The master and slave MCPs preferably have the same IP address for redundancy. If the master MCP fails, a seamless transition to the slave MCP occurs. Backhaul timing is a limited issue because information is transferred between a BTS and a BSC in one "box" and not across a longer distance as with a typical network. The configuration **80** further includes RANs **76** which do not contain an MCP but rather, are controlled by the master MCP **72** in RAN **70**. Each of the RANs depicted **70**, **70'**, and **76** include at least one transceiver **64**, power supply **82**, and GPS receiver **92** that synchronizes the timing between the BSC **12** and the BTS **14** and between the MCP **72** and the SCP **74** per information received from a database **91** and/or GPS related satellites.

The configuration **80** may also include a combiner **86** that may combine a plurality of frequency segments to a common transmission line or antenna, a power amplifier **88** (which is similar to power amplifier **66**), and a power supply **90** that could be used to re-set or re-start the RANs **70**, **70'**, and **76**. A switch hub **84** may be included to provide a single access (via, for example, an IP address), between the configuration **80** and the IP network **92**.

Although an exemplary embodiment of the system of the present invention has been illustrated in the accompanied drawings and described in the foregoing detailed description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth and defined by the following claims. For example, the capabilities of the invention can be performed fully and/or partially by one or more of the modules RANs **70**, **70'**, and **76**, and/or by one or more of the blocks **16-58**. Also, these capabilities may be performed in the current manner or in a distributed manner and on, or via, any device able to transfer information between the RANs, the blocks, and/or other components. Further, although depicted in a particular manner, various blocks may be repositioned without departing from the scope of the current invention. For example, the RCC **18** may be positioned in the BSC **12**, while the SDU **20** may be positioned in the BTS **14**. Still further, although depicted in a particular manner, a greater or lesser number of RANs and/or blocks may be utilized without departing from the scope of the current invention. For example, additional RANs **76** may be utilized in the configuration **80** of the present invention.

What is claimed is:

1. A modular and stackable Internet Protocol (IP) Radio Access Network (RAN) comprising:

- a combined base transceiver station (BTS) and base station controller (BSC) comprising:
  - a centralized Main Control Processor (MCP) coupled to a plurality of selector distribution unit (SDU) channel element control (CEC) Processors (SCPs);
  - each of the plurality of SCPs comprising an SDU coupled to a CEC;
  - a radio call control (RCC) coupled to the CEC, wherein the MCP comprises the RCC; and
  - a main call control (MCC) coupled to the SDU and to the RCC, the MCC is configured to receive a mobile station (MS) origination message from the RCC, the MS operating in the RAN, the MCC is further configured to

- request call service from a calling agent (CA),
- confirm the validity of the MS and resource information of a media gateway,
- communicate with the RCC to request a radio resource,
- communicate with the SDU to allocate a selector resource, and
- perform at least one of subscriber registration, call setup, call release and call handoff.

2. The IP RAN of claim 1 comprising an interoperability system (IOS) signaling control connection part (SCCP) in the MCP coupled to the MCC.

3. The IP RAN of claim 2, wherein the IOS and the SCCP are combined.

4. The IP RAN of claim 3, wherein the SCCP is adapted to communicate with a call agent.

5. The IP RAN of claim 1 comprising a packet control function (PCF) in the MCP coupled to the SDU.

6. The IP RAN of claim 5 comprising a first operation, administration, and maintenance (OA&M) module coupled to the PCF.

7. The IP RAN of claim 6, wherein the first OA&M module is adapted to communicate with a basestation manager.

8. The IP RAN of claim 6 comprising a configuration management (CM) block in the OA&M module, the CM block coupled to the PCF and to the CEC.

9. The IP RAN of claim 8 comprising a transceiver module coupled to a second OA&M module.

10. The IP RAN of claim 9, wherein the transceiver module is adapted to communicate with an IF chip, a transceiver, and a power amplifier.

11. The IP RAN of claim 5 comprising a call agent simulator (CA\_SIM) in the MCP coupled to the IOS SCCP.

12. The IP RAN of claim 5, wherein the PCF is adapted to communicate with a packet data serving node.

13. The IP RAN of claim 1, wherein the SDU is adapted to communicate with a gateway.

14. A system, comprising:

- a modular and stackable Internet Protocol (IP) Radio Access Network (RAN) including a combined base transceiver station (BTS) and base station controller (BSC) comprising:

- a first module including a control portion and a plurality of device portions;

- wherein the control portion includes a radio call control (RCC) module coupled to a main call control (MCC) module;

- wherein each of the device portions include a selector distribution unit (SDU) coupled to a channel element control (CEC) module and the MCC, the CEC coupled to the RCC; and

- a second module, coupled to the first module, including a device portion; and wherein the MCC is configured to

- receive a mobile station (MS) origination message from the RCC, the MS operating in the RAN, the MCC is further configured to
- request call service from a calling agent (CA),
- confirm the validity of the MS and resource information of a media gateway,
- communicate with the RCC to request a radio resource,
- communicate with a selector distribution unit (SDU) to allocate a selector resource, and
- perform at least one of subscriber registration, call setup, call release and call handoff.

**11**

**15.** The system of claim **14**, comprising a third module, coupled to the first module and to the second module, including a redundant control portion and a device portion.

**16.** The system of claim **15**, wherein the first module, the second module, and the third module are stackable.

**17.** The system of claim **15**, wherein the first module, the second module, and the third module are coupled via a switch hub.

**18.** The system of claim **15**, wherein the first module, the second module, and the third module include at least one of: a transceiver, a GPS receiver, and a power supply.

**12**

**19.** The system of claim **15** comprising a combiner adapted to combine a plurality of frequency segments from the first module, the second module, and/or the third module to a common transmission line or antenna.

**20.** The system of claim **15** comprising a power amplifier adapted to increase signal power from the first module, the second module, and/or the third module.

\* \* \* \* \*